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DISTRIBUTED SOURCE GENERATION FOR RF ENVIRONMENTAL MODELING FOR--ETC(U)
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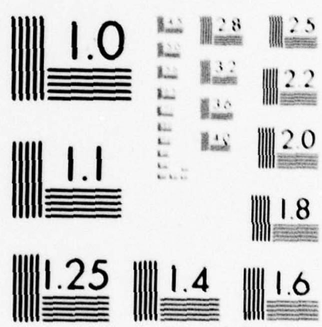

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TECHNICAL REPORT T-79-37

DISTRIBUTED SOURCE GENERATION FOR RF ENVIRONMENTAL MODELING FOR HARDWARE-IN-THE-LOOP MISSILE GUIDANCE SIMULATION

U.S. ARMY MISSILE RESEARCH AND DEVELOPMENT COMMAND

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12 March 1979

Approved for Public Release, Distribution Unlimited

Redstone Arsenal, Alabama 35809

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20. ABSTRACT (Continue on reverse side if necessary and identify by block number)

The basic simulation philosophy of the Advanced Simulation Center (ASC) is to incorporate as much missile hardware as possible into simulation. Errors associated with modeling nonlinear devices are thus avoided while increasing credibility of the simulation. However, this places a special burden on the simulators to display a realistic and comprehensive environment during the simulations because the seekers are stimulated at their operating wavelengths. The seeker is the more difficult subsystem to model properly and if it is to form valid responses to environmental stimuli, then the stimuli must → next page

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1. RFSS INTRODUCTION

The basic simulation philosophy of the Advanced Simulation Center (ASC) is to incorporate as much missile hardware as possible into the simulation. Errors associated with modeling nonlinear devices are thus avoided while increasing credibility of the simulation. However, this places a special burden on the simulators to display a realistic and comprehensive environment during the simulations because the seekers are stimulated at their operating wavelengths. The seeker is the more difficult subsystem to model properly and if it is to form valid responses to environmental stimuli, then stimuli must portray the correct time, space and frequency characteristics of the target, clutter, ECM and multipath.

The Radio Frequency Simulation System (RFSS), which has been operational since November 1975, is one of three physical effects simulators in the ASC. The RFSS consists of a large matrix array providing a 42-degree field-of-view driven by a multichannel microwave signal generation subsystem for environmental signal generation and display. Signals representing elements of the environment are transmitted from the array through a shielded, anechoic chamber providing a controlled RF environment. These signals are intercepted by seekers mounted on a three axis flight table at the opposite end of the chamber. The table provides the dynamic rotational forces of pitch, roll and yaw to the seeker during simulation. The guidance loop is closed through additional missile hardware and the control room computer complex. This real-time simulation configuration produces representative miss distance data and is especially effective for performing advanced ECM/ECCM evaluations with developmental or fielded jammers.

Inherent in the design of the RFSS is real-time control over the degrees of freedom required to model an element of the environment. These degrees of freedom are when and where a signal appears in the seeker field-of-view, frequency, power and polarization of the electromagnetic return wave. These controls have proven to be adequate for low resolution models in range, angle and doppler, but are constraining for high resolution models of distributed sources such as for extended targets, distributed clutter and diffuse multipath. This need to develop and implement distributed source models has been accelerated by the rapid advancement of active seekers providing high range resolution. Active seekers are being designed for the previously mentioned reasons, but, significantly, glint reduction in the end game intercept phase is a major objective. The simulator must therefore be capable of displaying high resolution models of the target, clutter and multipath. An ability to perform real-time delay of received seeker signals and coherent reprocessing of these signals for retransmission to the seeker is a necessary requisite to performance of a viable hardware-in-the-loop simulation.

2. ADVANCING MISSILE TECHNOLOGY

Missile technology in RF guidance is advancing rapidly today in the microwave as well as millimeter spectrum. This advancement is a direct result of solid-state component development, digital signal processing and the development of microcomputer devices. RF guidance concepts conceived years ago are now being explored and developed. In addition to holding forth the promise of fire and forget all-weather capabilities, low cost and lightweight, high performance missiles, most of these techniques provide high resolution through new sophisticated waveforms.

Spiraling costs of missile hardware and flight test coupled with the increasing complexity of missile systems and threats have spurred the development of hardware-in-the-loop missile guidance simulators. These simulators bridge the gap between analysis and flight tests by incorporating hardware elements of the missile system such as the seeker and guidance processor into a real-time simulation. Technically, these simulations accomplish a thorough mapping of the performance envelope of the missile system in a controlled, representative environment. Simulations serve to enlarge the technical data base for resolution of technical issues, and to support effective management decision making by providing meaningful answers to tough system questions while controlling system costs.

Since missile guidance systems are developed for a wide range of applications and purposes, these systems exhibit a diversity of RF guidance techniques and waveforms, providing varying range, angle and doppler resolution. Accordingly, a diversity of mathematical models emanate from efforts to model the physical RF environmental phenomena interacting with the seekers. Furthermore, there is no technical consensus for universal acceptance of a model for targets, clutter and multipath. Empirical as well as stochastic representations have long been employed for these models. The advent of high resolution seekers has placed the modeler in something of a technical dilemma because there is no handbook or universally accepted approach for mathematical environmental modeling.

There is a strong motivation to employ deterministic models to represent RF distributed sources. Real-world extended targets, distributed clutter and diffuse multipath create asymmetrical power density spectra which do not conform to familiar probability density functions. Tailored deterministic modeling techniques to provide control over the time, spatial and frequency characterization of these distributed phenomena can provide realistic seeker performance evaluation. Deterministic modeling enables the building of a data base from which stochastic representations can evolve. This approach allows an opportunity to gain new insight into the nature and behavior of a particular

target for example. Verification of these modeling techniques permits similar development of models for other target types quickly without resorting to measurement programs or overly simplified statistical models. Furthermore, deterministic model characterization enables the performance analyst to pose a hypothesis, to design and conduct an experiment to test the hypothesis, and to perform the analysis to verify or modify the hypothesis through simulation feedback.

The staff of the RFSS has been involved for a number of years in developing the RF environmental modeling rationale described above. Efforts have been concentrated on providing a simulation tool for distributed source model implementation which could accept a diversity of models, structure and techniques whether stochastic or deterministic in nature. A framework or skeleton is being developed in the RFSS for model implementation. The basic element providing this capability is the Distributed Source Generation System (DSGS).

The DSGS under development in the RFSS will permit representation of extended targets, distributed clutter and diffuse multipath in a hardware-in-the-loop simulation and is being developed in a two-phase effort. The Interim DSGS will be completed in FY 78 and will permit modeling of one extended target in a benign environment or a simple target in distributed clutter. The second phase of effort will permit modeling of multiple targets in a distributed clutter environment.

The development of the DSGS is one of the USAMIRADCOM Technology Laboratory goals for FY 78. Conceptual definition and preliminary design were accomplished during FY 76-77 supported by $250,000 of A-214 Simulation Research funds. The FY 78 effort on the Interim DSGS in Simulation Research is $208,000. Special Purpose Equipment funds amounted to $448,000 in FY 78, supplemented by $300,000 of customer funds. Completion of the DSGS will require approximately $500,000. The establishment of the DSGS capability in the RFSS will be a major engineering accomplishment and will provide the RF seeker community a significant simulation capability for the coming decade.

3. MATHEMATICAL ENVIRONMENTAL MODELS

The RF environment of a missile seeker includes radar returns from a desired target, other aircraft, reflections from the earth's surface, airborne material, and ECM. These signals may be characterized in terms of their amplitude and phase spectra, their time of arrival, and their direction-of-arrival. Because of the complexity of these signals, an exact duplication of the real-world RF environment in hardware-in-the-

loop simulations is an impossible task. Therefore, the objective of the RFSS environemental modeling effort has been to provide the seeker with signals which will induce the same missile response as in an actual engagement. Thus the modeling requirements are directly related to the seeker resolution in range, angle, power and doppler, and the intelligence of its processor.

The development of environmental models suitable for a given seeker requires two levels of modeling. The first level is a mathematical model which approximates each scatterer as one or more simpler reflectors for which the reflection problem is mathematically tractable. The total reflection from the scatterer is formed by coherently superimposing the component reflections. The inputs to the mathematical model are the locations relative to the seeker and reflection properties in the direction of the seeker of the component reflectors. The outputs are the time delay, doppler shift and range attenuation for the centroid of the return, and the relative amplitude, phase and direction-of-arrival of the instantaneous return voltage as a function of time over the duration of the waveform.

The second level of environmental modeling is the development of a suitable RF model for implementation in the simulation system hardware. Because of the limitation on the number of independent RF channels available for implementation of the RF model, it is impossible to generate exactly the radar return waveforms computed in the mathematical models. However, RF models have been developed which, because of the finite resolution of the seeker, induce the proper missile response and thus fulfill the objective of hardware-in-the-loop environmental modeling. A discussion of specific RF models is deferred until Section 4. The following is a description of typical mathematical models used in hardware-in-the-loop simulations.

A. AIRCRAFT MODELS

The aircraft mathematical models developed are of the type normally encountered by air defense missile systems, namely, jet aircraft and helicopters. These models range in complexity from statistical single scatterer models to deterministic multiple scatterer models. Each model has its own particular area of application depending on seeker resolution and its own particular set of advantages and disadvantages.

(1) STATISTICAL SINGLE SCATTERER MODELS. In these models, the instantaneous reflections from the aircraft occur at a geometrical point in space and fluctuate in amplitude and direction-of-arrival according to a predetermined statistical density and autocorrelation. In the simplest models, the variances of the densities and bandwidths of the power spectra are fixed. In more sophisticated models, the variances are allowed to change with target aspect and the bandwidths are increased or decreased to agree with the instantaneous line-of-sight angular rates.

The advantages of the simpler models are their usefulness in providing baseline performance data and the speed with which changes in target-missile relative geometry may be updated on the RFSS array. The disadvantages are the uncertainty in the validity of specific statistical densities and power spectra, and, when applicable, the lack of range extent.

(2) EMPIRICAL SINGLE SCATTERER MODELS. These models employ empirically derived RCS and glint data to determine the fluctuations as a function of aspect. Thus, a greater confidence in these models is inspired, provided that adequate empirical data is available. These models suffer from either incompleteness of the empirical data or a potentially large computer data storage requirement and a lack of range extent.

(3) EMPIRICAL/STATISTICAL SINGLE SCATTERER MODELS. In these models, the means, variances and/or bandwidths of the target statistics are inferred from empirical data. This alleviates the computer data storage problems of the empirical models while retaining their essential characteristics. Again, however, there is an uncertainty in the validity of the statistical functions used and a lack of range extent.

(4) DETERMINISTIC MULTIPLE SCATTERER MODELS. To circumvent the problems of statistical validity and to add range extent to the simulated target, deterministic multiple scatterer target models were developed. These models are based on the assumption that a target may be represented electrically as a collection of component scatterers, each of which is described by a phase center location and a scattering amplitude. Both parameters may vary with aspect. The amplitudes and phase center locations are chosen to produce target RCS and glint patterns which are essentially indistinguishable from empirical target data.

The usual starting point for developing a multiple scatterer model for a specific aircraft is a geometrical model in which all the major scatterers on the aircraft are approximated by one member of a set of standard shapes. The dimensions and locations of the shapes are iteratively adjusted until the computed RCS and glint essentially agree with empirical data. The phase centers and scattering patterns of the geometrical scatterers are then computed as a function of aspect in the target coordinate system. These data provide the basis for the deterministic multiple scatterer model.

The distributed nature of the target is included in this model via the spread in component scatterer phase center locations. The component scatterer positions and amplitudes are sufficient slowly varying with aspect that the computer data storage requirement is not prohibitive. The

fluctuations in target return amplitude, phase and direction of arrival are all inherent in the model, requiring no statistical model. The update rates for these models are slowed significantly over the simpler models because of increased data access and computation times. Care must be taken to avoid aliasing distortion caused by undersampling at high aspect angular rates.

(5) ROTATING BLADE MODULATION MODELS. Seekers which track in doppler may have the problem of locking up on spectral lines generated by a rotating blade (jet engine turbines or helicopter hub and blades). In view of this, a general blade modulation model has been developed which can produce doppler spectra associated with a large class of blade modulations. In addition to producing the appropriate spectrum, essential characteristics of the modulation waveform, such as the specular flash associated with helicopter blade modulation, are preserved. The model computes the time functions associated with reflections from a blade scattering model. These time functions are sampled at a rate appropriate for the seeker processing bandwidth, taking care to avoid aliasing distortion caused by undersampling the higher frequency components. The blade model is aspect sensitive to provide realistic emergence and fading of the spectral lines. Both amplitude and phase effects are included so that the modulation spectra may be asymmetric with respect to the skin return.

B. CLUTTER MATHEMATICAL MODEL

The major source of target signal interference is often reflections from the earth's surface. Because the number of individual scatterers is large, a statistical model is required for real-time simulations. The basic approach is to lay out a grid structure over the earth's surface, calculate the return from each grid point and compute the total return as a weighted sum of all the grid point returns. The amplitude and phase of the return from each grid point are statistical variables depending on the scattering properties of the surface at that point and the seeker transmit and receive antenna patterns. The frequency of the return from each grid point is determined by the doppler shift associated with the direction to the grid point relative to the velocity vector of the missile. The time delay is determined by the range to the grid point.

For a given instantaneous orientation of the seeker antenna relative to the ground and for a given position and velocity of the missile, the total clutter return will be characterized by specific statistical amplitude and phase densities and a specific power spectral density. These functions may be calculated off-line and related to missile-ground geometry and dynamic parameters. In real-time simulations, the instantaneous clutter characteristics can be quickly determined from a few engagement parameters.

In the currently used clutter simulations, the power spectral densities appropriate for the three channels of a monopulse seeker are determined from the appropriate engagement parameters. The amplitude and phase of the Spectral Components are then randomized according to preselected probability densities. A correlation among the three monopulse channel signals is obtained by properly combining and filtering three independent randomizing sequences. A discrete time function is derived from each spectrum using the Fast Fourier Transform. The means and variances of the amplitude densities and the value of the doppler shift are determined from the engagement parameters. Statistically independent clutter signals are computed for each seeker range cell.

C. MULTIPATH MATHEMATICAL MODELS

The image of the target created by the conducting surface of the earth creates a radar return which exhibits fluctuations highly correlated with the direct return. A realistic multipath model is difficult to achieve because the correlation is very sensitive to local irregularities in the earth's surface.

The most satisfactory multipath model appears to consist of reflecting the scatterers of a multiple scatterer model through a perfectly conducting plane and adding small, uncorrelated random perturbations to the positions, amplitudes and phases. The peak amplitude of the image return must be scaled relative to the direct return according to the losses resulting from the added path length and the reflection from a lossy conductor.

D. ECM MATHEMATICAL MODELS

Hardware-in-the-loop simulation offers an ideal test bed for testing potential or actual ECM techniques. Using the RFSS multiple target capability, a wide variety of jamming signals can be simulated, from brute-force noise jamming to intelligent, repeater jamming.

The mathematical models developed thus far have dealt with warped phase front techniques applied to monopulse seekers. These models consist of phased, repeating sources used to enhance target glint. Each source along with the target skin return is treated as a separate target. The phasing is computed as the range phase plus an insertion phase delay. The insertion phase and amplitude of one or more of the repeater sources is varied in a manner prescribed by the particular ECM technique being tested.

In addition to developing mathematical models of potential ECM techniques, hardware-in-the-loop simulations allow the testing of actual ECM hardware against actual missile hardware. in these cases no mathematical model is required.

4. RF ENVIRONMENTAL MODELS

The mathematical models discussed in the previous section are used to compute the return waveform received by the seeker from a given source. The RF model bridges the gap between the mathematical description of the return signal and the actual control commands sent to RF and IF components of the simulation system. The mathematical model outputs the time delay and doppler shift of the return centroid, which can be translated directly into hardware commands. The mathematical model also computes the amplitude, phase and direction of arrival as a function of time over the duration of the return waveform. Because of switching and modulation bandwidth constraints, these outputs cannot be translated directly into hardware commands. It is necessary to approximate the desired waveform using a limited number of RF channels, each of which can be updated at rates slow compared to the changes required in the mathematically computed waveform.

A. AIRCRAFT RF MODELS

A non-range extended target returns a single pulse for each incident pulse. The amplitude, phase and direction-of-arrival fluctuate from pulse to pulse. A range extended target returns a waveform which has a longer time duration than the incident pulse. The amplitude, phase and direction-of-arrival vary in a continuous manner over the return waveform time duration.

To simulate a range extended target, it is necessary to approximate the waveform modulation called for in the deterministic multiple scatterer mathematical model. This is done by taking discrete samples of the computed return waveform modulations and applying them to delayed replicas of the incident waveform. The successive delays are equal to the modulation sampling interval. Each delayed component of the incident pulse is treated as an independent target, being amplitude and phase modulated independently and transmitted from an independent position on the array.

The time delays are small enough so that the seeker is unable to resolve the discreteness of the individual return pulses. When the discrete pulse train is combined in the seeker, a signal essentially identical to the waveform computed in the mathematical model results.

B. BLADE MODULATION RF MODELS

The amplitude and phase modulations created by a rotating blade are bandlimited to the seeker processing bandwidth by the mathematical model. The update rates required for the bandlimited modulations are well within the capabilities of the RF hardware.

The blade modulation may be superimposed directly onto the skin return to form a composite scatterer. Alternatively, the blade may be considered as an additional set of scatterers in the multiple scatterer target model. The reflections of these additional scatterers are then added coherently to the other scattering signals with the proper time delay. The composite waveform is then sampled and used to modulate the delayed pulses in the usual manner.

C. CLUTTER RF MODELS

Because of the wide angular distribution of clutter, it is time consuming to calculate an equivalent direction-of-arrival as a function of time over the duration of the returned waveform. To overcome this limitation, the monopulse channel signals are computed separately for independent radiation into the appropriate channels.

The essential characteristics of clutter are the autocorrelations in each channel and the cross-correlations between channels. Thus, it is important to carefully preserve the relationships between the monopulse channel signals computed by the mathematical models. This is accomplished by separately modulating three independent RF channels to create the three channel signals. These three signals are independently radiated into the appropriate seeker channels by positioning each radiation source on the array such that the gain for the desired channel relative to the other two channels is high. For example, the sum channel source should be positioned at the seeker antenna boresight where the sum channel gain is high and the difference channel gains are low. The position chosen for the azimuth difference source is where the azimuth difference gain is high relative to the sum and elevation difference gains, and the position for the elevation difference source is chosen in a similar manner. The three sources must necessarily track the footprint of the seeker antenna on the array.

For each channel, the waveform must be extended to cover the full unambiguous range interval of the seeker. This is accomplished by creating independent random modulation samples for each range resolution cell and applying them to replicas of the incident waveform delayed in time by the appropriate amount. As with the aircraft models, the time delay increment is chosen to be sufficiently small so that the seeker response is identical to its response to a continuous waveform. Although for a given monopulse channel, each range cell signal is statistically independent, each has the same power spectral density. The shape, amplitude and doppler offset of the spectra change with the instantaneous engagement parameters.

5. DISTRIBUTED SOURCE GENERATOR RF HARDWARE

The distributed source generator is the RF, digital and interface hardware

necessary to create the time delay, doppler frequency, amplitude and phase modulations described in the preceding section. This processing must be coherent to permit simulation of coherent active seeker returns.

A. COHERENT PROCESSING

For coherent seekers, it is important to return a waveform which, except for a doppler shift, is phase coherent with the transmitted waveform. This is accomplished in the distributed source generator by processing the pulses transmitted from the seeker and retransmitting these processed pulses back to the seeker. The processing consists of time delaying, amplitude and phase modulating, and doppler shifting. Extreme care must be taken to avoid spurious modulations which could spread the return spectrum over more than a doppler resolution cell.

The seeker pulses are received by the array antennas from which the target or clutter signals are transmitted. The received pulses are translated down to an IF frequency for processing. The processed pulses are retranslated to the seeker frequency amplified and transmitted across the chamber to the seeker.

B. TRUE TIME DELAY

For coded waveform seekers, it is necessary to employ true time delays to obtain the return waveform centroid delay. This delay must be continuously variable to simulate a continuous change in target-missile range.

For each RF channel, the continuous delay is realized by a combination of discrete delays and a single continuously variable delay. The discrete delays are generated by transmitting an S-band signal through a bulk acoustic wave crystal. The acoustic wave is launched and received at either end of the crystal by piezoelectric transducers. Because the crystals are nondispersive, the coherency of the transmitted signal is maintained to a high degree. Multiple reflections inside the crystal are avoided by inclining the receiving transducer face relative to the transmitting face. Signals reflected off the receiving transducer are dispersed by the succeeding reflections at the crystal boundaries.

The continuous delay also employs a bulk acoustic wave crystal, launching the wave in the same manner as for the discrete delays. To obtain the continuous delay characteristic, the acoustic wave is picked off after a selected delay by a laser beam focused at the appropriate point along the crystal transmission axis. The acoustic traveling wave produces a spatially periodic modulation of the crystal material density, resulting in Bragg scattering of a component of the optical beam at the intersection of the optical and acoustic beams. The scattered beam is shifted in frequency by the IF and is coherently modulated by the IF signal waveform. The scattered and unscattered beams.

are aligned and focused onto an optical mixer, which translates the delayed waveform from the optical frequency to IF.

The delay may be continuously changed by changing the position of the intersection of the laser beam with crystal axis. In actual operation, the laser is held fixed and the crystal is moved to vary the delay. The continuously moving crystal produces a doppler shift in the output which must be taken into account when adding the target or clutter doppler shift.

The delay can be increased or decreased by reversing the direction of travel of the linear motor driving the crystal carriage. In order to suppress multiple reflections, an individual crystal must be used for each direction of travel. The end of the crystal opposite to the launcher is textured to absorb the acoustic wave and prevent reflections.

C. TAPPED DELAYS

As discussed earlier, target and clutter range extent is simulated by creating a series of amplitude, phase and direction-of-arrival modulated pulses for each incident pulse. The pulse train is created coherently by employing tapped delay lines with a tap spacing dictated by the seeker range resolution.

The tapped delays are composed of coaxial delay lines connected in series. At each junction a power divided routes part of the signal through a leveling amplifier and out of the delay line. The variable delay device supplies the input. The outputs are amplitude and phase modulated and transmitted from a selected location on the array to produce the correct direction-of-arrival. For a target, the number of taps required is determined by the maximum range extent of the target. For clutter, the number of taps required is determined by the number of seeker range cells in its unambiguous range interval.

D. DIGITAL QUADRATURE MODULATION

The amplitude and phase modulation of the tapped delay signals is accomplished by digitally generating quadrature modulation components. Ordinary modulation techniques proved unacceptable because of their relatively high spurious modulation levels. It is required that the incidental modulation be sufficiently low so as to produce spurious frequency components less then the sub-clutter visibility of the seeker (minus the coherent processing gain).

Because the quadrature modulation is created in the digital domain, spurious phase modulations and the amplitude modulations are nonexistent and the amplitude modulation errors are defined by the digital quantization level. After multiplexing the two quadrature components and digitally filtering, the resulting digital signal is converted to an

analog signal and translated in frequency to the seeker operating frequency by mixing the modulation signal with the seeker pulses at the tapped delay outputs. This single mixing process is equivalent to modulating the quadrature components of the pulsed carrier and combing.

E. PULSE REPETITION INTERVAL MEASUREMENT SYSTEM

The clock rate of the Digital Quadrature Modulator must be precisely tied to the seeker PRI. This is accomplished by continuously measuring the PRI to provide a control signal for the modulator clock. In the event of a change in PRI, the clock frequency will automatically switch to the appropriate value.

The RF pulses are detected, amplified and fed into a frequency counter. After each counting interval, the counter provides a control word to the modulator to control the clock frequency.

6. DISTRIBUTED SOURCE GENERATOR DIGITAL CONTROL

The digital hardware used to control the distributed source generator hardware includes a general purpose computer (Harris/6), an array processor (Floating Point Systems AP120B), and a microprocessor (Data Equipment Corporation LSI-11).

A. HARRIS/6

The general-purpose computer does the target and clutter centroid geometrical calculations and passes on dynamic geometrical parameters to the array processor and the microprocessor.

B. AP120B

The AP120B is an array processor and, as such, is optimized toward high speed parallel computations. For the multiple scatterer target model, the individual scatterer reflections are calculated, based on the geometrical parameters input by the /6. The results are summed over all scatterers and sampled to generate the tapped delay signal modulation. For clutter, the AP120B does FFT's and generates correlated random sequences.

The outputs of the AP are inputs for the Digital Quadrature Modulator.

C. LSI-11

This microprocessor controls the variable time delays. Based on inputs from the /6, the LSI-11 generates commands for delay and delay rate. It is part of a feedback loop which controls the continuous delay rate input to minimize the delay position error. The continuous delay position is read by an optical encoder mounted on the crystal carriage. The optical encoder output is read into the microprocessor. The LSI-11 is also

programmed to perform many delay calibration functions.

7. DSG COHERENT ACTIVE TEST SYSTEM

The DSG Coherent Active Test System is designed to perform calibration and operational check measurements on the DSG. In addition, the system will be used to verify the various environmental models.

The Test System is composed of an RF source, a transmitted pulse modulator, separate transmitting and receiving antennas, and a receiver. The receiver is a coherent heterodyne system with outputs available at a selectable IF or video frequency. The receiver is range gated with a variable width range gate. The video is produced by filtering out all but a single PRF sideband.

This system provides a means of calibrating the DSG time delays by comparing the transmitted pulse with the received pulse position on an oscilloscope or by adjusting the range gate delay for maximum signal power.

The amplitude and phase modulation can be checked by inputting the video output to a network analyzer.

Target models can be verified by RCS patterns by rotating the target on the array and recording the video output level.

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